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RESEARCH ARTICLE

Positive Psychosocial Factors in Childhood Predicting Lower Risk for Adult Type 2 Diabetes: The Cardiovascular Risk in Young Finns Study, 1980–2012

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Introduction: Type 2 diabetes is a public health concern, but psychosocial factors that may protect against the disease are unknown. This study examines whether a positive psychosocial environment in childhood is associated with lower risk for Type 2 diabetes in adulthood or healthier glucose trajectories over the life course, and whether BMI mediates the associations.

Methods: A cohort of 3,596 Finnish children was followed into adulthood over 32 years. An overall positive psychosocial score, consisting of six subdomains, was measured at study baseline (1980). Relative risk ratios and multilevel growth curve modeling were used to examine associations of the psychosocial score with Type 2 diabetes (2012) and glucose trajectories (1986–2012). The mediating effect by BMI was examined using mediation analysis. The analyses were conducted between June 2015 and January 2016.

Results: There was a 21% decrease in the rate of Type 2 diabetes (relative risk ratio, 0.79; 95% CI=0.66, 0.94) for each 1-SD increase in the positive psychosocial score after adjustment for childhood cardiovascular risk factors and dietary behaviors. Adult BMI mediated 52% and weight gain mediated 25% of the association. The growth curve model showed healthier glucose trajectories (age X psychosocial score interaction, b= –0.01; p=0.010) for participants with higher versus lower positive psychosocial score in childhood.

Conclusions: Positive psychosocial environment in childhood seems to have beneficial influences on the risk for Type 2 diabetes over the life span. RCTs will be required to see if interventions directed at early-life circumstances are warranted.

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INTRODUCTION

Type 2 diabetes is one of the most important contemporary public health challenges.[1,2] There are 29.1 million people with diabetes (of whom 90% have Type 2 diabetes) in the U.S. and it has been estimated that one in three Americans will develop disease by 2050.[3] Although Type 2 diabetes is usually diagnosed later in life, the silent process underlying manifestation of the disease starts decades earlier.[4,5] An alarming new trend is that Type 2 diabetes is developing in younger people more than seen previously,[1,6] thus suggesting a need for more efficient early prevention.[6]

The developmental roots of adult health lie in early life, as a mixture of genetic and environmental factors.[7,8] Although early-life interventions have traditionally focused on reducing risky health behaviors (e.g., unhealthy diet),[9] there is growing recognition that the effects of such prevention efforts remain limited if the social and psychosocial contexts are ignored.[6,10–12] Identifying psychosocial factors in early life that may protect from developing Type 2 diabetes over the life course may help to target early prevention more effectively. For children and adolescents, the family's social and emotional situation powerfully defines the social context, setting the foundation for many of the factors that matter for life course health.[7,13]

Most research on psychosocial factors identifies whether harmful factors are present[14–20] and evaluates their contribution to future disease. Recent evidence suggests, however, that positive environmental and personal attributes play a protective role in health, and therefore it may be valuable to identify these as well.[21–24] Even with extensive research on risk factors, it has not yet been determined how to reduce the burden of diabetes. In fact, research focusing on identifying protective factors may provide new insight, given that recent findings have suggested that the absence of harmful factors does not necessarily indicate the presence of factors that actively promote adaptive functioning.[25,26] Greater understanding of how to attain and maintain positive health outcomes will be achieved by examining the full spectrum of factors that contribute to health.[21,25,26] Such effort will require identifying factors that not only accelerate risk but also may promote restoration and serve as "health assets."[21] Children with supportive parenting,[27,28] high environmental stability,[29] good ability to regulate negative emotions,[14,24,30] and a combination thereof[31,32] appear to be well protected against health risks, but whether these factors protect against Type 2 diabetes has not been examined previously.

Using follow-up data over 32 years, the current study examines whether a combination of psychosocial factors across distinct domains—including economic, social, emotional, health behavioral, and dispositional—in childhood is associated with lower rates of Type 2 diabetes or pre-diabetes (indicating early signs of diabetes)[33] in adulthood or with healthier development of glucose levels from childhood to adulthood. To elucidate potential explanatory mechanisms, BMI is examined as an intermediate pathway from childhood factors to Type 2 diabetes.

METHODS

Study Population

The Cardiovascular Risk in Young Finns Study is a 32-year follow-up study set up to determine the contribution made by childhood lifestyle, biological, and psychological measures to the risk of cardiovascular diseases in adulthood.[34] The participants (N=3,596) were randomly chosen from the population register of Finland, aged 3–18 years at study baseline in 1980, and followed up regularly until 2012.

Participants with Type 1 diabetes at the baseline (n=19) or at any of the follow-up visits (n=24) were excluded, yielding a baseline sample of 3,553 participants of whom 2,044 remained until 2012 (Appendix Figure 1, available online). Known reasons for dropping out were moving abroad (n=72); address unknown (n=49); death (n=104); or written withdrawal from the study (n=122). Attrition analyses showed that younger age and lower score on positive psychosocial factors in childhood predicted higher probability of dropping out from the study, but cardiovascular risk factors or dietary behaviors had no effect (Appendix Table 1, available online). Informed consent was obtained for all participants (from parents for children aged <12 years). The study plan and data collection procedures were approved by the universities and the local ethics committees.

Measures

Parents were asked to respond to a questionnaire in 1980. A total positive psychosocial score, which has been associated with favorable cardiovascular health outcomes in prior work,[32,35] was formed. It was based on the following six subdomains:

1. Favorable SES consisted of parental occupational status (manual/lower white collar/higher white collar); parental educational level (comprehensive/secondary/tertiary); family annual income (8-point scale); and being active in work life (unemployed versus employed). Item scores were standardized and summed together (mean, 0.25; SD=2.85) for a total score.
2. Favorable emotional environment consisted of parental mental health diagnosis (yes/no); a parental caregiving nurturance scale[36] (mean score of seven items shown in Appendix Table 2, available online, α=0.70); parental life satisfaction scale (mean score of three items shown in Appendix Table 2, available online, α=0.70); and parental healthy alcohol use (8-point scale of the frequency of intoxication). Alcohol use was included because of its known associations with child emotional development.[37] Item scores were standardized and summed together for a total score (mean, −0.01; SD=2.30).

3. Parental health behaviors were assessed as non-healthy versus healthy BMI (<30.0 vs ≥30 kg/m^2); smoking (yes/no); and frequency of exercise (none/sometimes/regularly). Behaviors were assessed from the mother and the father, standardized and summed together (mean, 0.06; SD=3.00).
4. Absence of stressful events included events previously associated with cardiac outcomes[29]: moving residence, change of school, parental divorce or separation, death of a family member, and serious disease in the family (standardized and summed together; mean, 0.01; SD=2.22).
5. Self-control of the child was assessed using two scales completed by the primary caregiver.[32,36] The physical self-control scale consisted of four statements among which the parent was asked to choose the most accurate statement (Appendix Table 2, available online). Aggression control was the mean score of six items (Appendix Table 2, available online). Scores from the two scales were standardized and summed together (mean, 0.01; SD=1.74).
6. Social adjustment of the child was assessed via three statements drawn from previous research[31,40] among which the parent was asked to choose the most accurate one (e.g., *I am not particularly worried about my child's behavior*; standardized mean, 0.0; SD=1.0).

The total positive psychosocial score was formed according to previous recommendations on assessing cumulative childhood experiences.[38] Scores from the six subdomains were first standardized (for equal weight) and then summed together. This yielded a score that was normally distributed (Appendix Figure 2, available online). Factor structure was tested by structural equation modeling. A model with the total score and six subdomains showed acceptable fit (χ^2[300]=3456.5, comparative fit index=1.000, standardized root mean residual=0.084, root mean square of approximation<0.05) and the confirmatory factor analyses showed that the individual items loaded on the hypothesized domains (Appendix Table 3, available online).

Child's BMI, blood pressure (from the brachial artery), serum insulin, serum low-density lipoprotein cholesterol, and high-density lipoprotein cholesterol were taken from venous blood samples in 1980.[34] Dietary habits of the child were reported by the parent using the validated Food Frequency Questionnaire as weekly consumption of vegetables, fruit, meat, and fish (range, 0–38).

Glucose was measured in 1986, 2001, 2007, and 2012 after a 12-hour fast. Venous blood samples were drawn, and plasma immediately separated and stored for batch analysis. Plasma concentrations of glucose were determined using enzymatic hexokinase method.[34] BMI was measured in 2001, 2007, and 2012 by trained personnel as weight [kg] / [height (m)]^2.

Participants were classified as having Type 2 diabetes in 2012 if any of the following criteria were met:

1. Fasting plasma glucose value was ≥7 mmol/L at any of the follow-up visits (2001, 2007, or 2012).
2. They reported having been given a Type 2 diabetes diagnosis by a physician.
3. Hemoglobin A1c was ≥6.5% (48 mmol/mol) at the 2011 follow-up.
4. They reported taking glucose-lowering medication at the 2007 or 2011 follow-up.
5. Type 2 diabetes diagnosis was made by a physician, based on the National Social Insurance Institution Drug Reimbursement Registry, which covers all Finnish citizens since 1990.

Women reporting gestational diabetes were classified as not having Type 2 diabetes if plasma glucose was <7.0 mmol/L. Prediabetes was defined as fasting glucose levels of 5.6–6.9 mmol/L (100–125 mg/dL).

Statistical Analysis

Missing data were imputed using multiple imputation with the chained equations procedure. The imputation model contained all the study predictors and outcomes,[39] and missing data both in the predictors and outcomes were imputed. Estimates in ten data sets (N=3,553) were calculated, and the findings are reported by pooling them together.

Relative risk ratios and 95% CIs were calculated to examine the association of the total positive childhood psychosocial score and each of its subdomains with Type 2 diabetes and prediabetes in adulthood. Pseudo-R^2 values and change in these values were calculated to examine the incremental effect of adding covariates as follows:

1. no adjustment;
2. adjusted for age and gender; and
3. additionally adjusted for cardiovascular risk factors and dietary behaviors in childhood.

Potential mediating roles of adult BMI (average across three measurements obtained in 2001, 2007, and 2012) or adult weight gain (change score in BMI from 2001 to 2012) in the associations were examined using the binary mediation procedure. The mediation proportion was the size of the indirect effect (using bias-corrected bootstrapping with 5,000 resamples) relative to the total effect.

The association between having a positive psychosocial score in childhood and longitudinal glucose trajectories was examined using growth curve modeling (random-intercept and random-slope multilevel models). Repeated measurements of glucose were nested within participants, each participant contributing up to four glucose measurements with age (centered) as a time-varying covariate. To examine the shape of the glucose trajectory, fixed linear age (centered age) and quadratic age (centered age^2) were included in the first model. Thereafter, interactions between the age terms and the psychosocial score were entered. A random-slope component was added for the linear effect of age to allow different individuals to follow more or less steep trajectories. The models were fit using unstructured error covariance matrix, including covariance between the intercepts and the slopes. All statistical analyses were conducted in Stata, version 13.1, between June 2015 and August 2016.

RESULTS

Mean glucose levels increased from 4.63 to 5.44 mmol/L. Prevalence of Type 2 diabetes was 3.4% (n=120) and prevalence of prediabetes was 33.4% (n=1,172) in imputed data. (Appendix Table 4 [available online] provides values for observed data.)

Table 1. Relative Risk Ratios (RRRs) of Adult Type 2 Diabetes and Prediabetes for 1 SD Increase in the Positive Psychosocial Score

	Outcome: Type 2 diabetes			Outcome: prediabetes		
Model	**RRR (95% CI)**	**Pseudo-R^2**	**Δ Pseudo-R^2**	**RRR (95% CI)**	**Pseudo-R^2**	**Δ Pseudo-R^2**
Model 1[a]	0.72 **(0.61, 0.86)*****	0.014		0.89 **(0.84, 0.95)****	0.003	
Model 2[b]	0.75 **(0.63, 0.88)****	0.039	0.025	0.91 **(0.85, 0.97)****	0.025	0.025
Model 3[c]	0.79 **(0.66, 0.94)****	0.074	0.035	0.92 **0.86, 0.98***	0.033	0.008

Note: Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$).
Δ indicates change in value.
[a]Positive psychosocial score as predictor with no adjustments.
[b]Adjusted for age and gender.
[c]Adjusted for age; gender; childhood cardiovascular risk factors (insulin, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, systolic blood pressure, BMI); and childhood dietary behaviors (fruit, vegetable, meat, and fish consumption).

Table 1 shows a decrease of 21% in the rate of Type 2 diabetes (p=0.008) and a decrease of 8% in the rate of pre-diabetes (p=0.011) with each 1-SD increase in the positive psychosocial score after adjusting for all covariates. The pseudo-R^2 showed that the fully adjusted model explained 6% more of Type 2 diabetes and 3% more of pre-diabetes compared with the model with no adjustments. There were no modifying effects of sex (Appendix Table 5, available online) or age (Appendix Table 6, available online) in the associations. In absolute terms, the findings showed that 2.5% (n=20) versus 5.0% (n=42) of participants with high versus low total positive psychosocial score (as defined by the highest quartile) had Type 2 diabetes. This means an absolute difference of 22 affected people from the total of 120 with Type 2 diabetes.

Associations of the psychosocial subdomains with Type 2 diabetes are shown in Table 2. Adjusting for all covariates, each 1-SD increase in healthy parental behaviors was associated with 23% reduced risk for Type 2 diabetes (p=0.003), and each 1-SD increase in the domain "absence of stressful events" was associated with 14% reduced risk of Type 2 diabetes (p=0.040) and with 7% reduced risk for pre-diabetes (p=0.045).

Having a higher total positive psychosocial score in childhood was associated with lower average BMI (standardized regression coefficient [β], −0.60; $p<0.001$) and less weight gain over the 11 years (β= −0.24, p=0.007). Average BMI mediated 52% (indirect effect's β, −0.06; 95% CI= −0.09, −0.04) and weight gain mediated 25% (indirect effect's β, −0.02; 95% CI= −0.05, −0.01) of the association between the total positive psychosocial score and having Type 2 diabetes.

Linear regression analyses showed that higher psychosocial score was associated with lower glucose level at each follow-up examination, adjusted for baseline glucose (β= −0.06, −0.04, −0.06, and −0.04, p=0.016. 0.0489, 0.006, and 0.015). The growth curve model showed that, on average, glucose levels rose in a curvilinear fashion over time (Figure 1, unstandardized beta [b] for age, 0.03, $p<0.001$; b for age^2, 0.01, $p<0.001$). Adding the psychosocial score into the model showed a significant interaction with the linear (but not with the quadratic) age term. Thus, the final model included the (linear) age X total psychosocial score interaction (b= −0.01, p=0.010) as well as terms for (linear) age, age^2, the positive psychosocial score, and sex (b=0.03, 0.01, −0.06, and 0.24, p-values <0.001). Figure 2 depicts this interaction, showing healthier glucose trajectories for participants with a higher versus lower level of positive psychosocial score (based on quartile split).

DISCUSSION

This study following individuals prospectively over 32 years showed that a set of positive psychosocial factors in childhood predicted a 21% reduction in risk for Type 2 diabetes in adulthood. The association remained after taking into account the effect of traditional cardiovascular risk factors known to predict Type 2 diabetes. Positive childhood factors were also associated with slower pre-diabetic development, as evidenced by a less rapid rise in glucose levels in people with more positive childhood factors. BMI explained a significant part of the observed associations, suggesting that attaining or maintaining a healthy body weight is one mechanism by which positive childhood experiences may exert a protective effect against later Type 2 diabetes.

These findings extend previous evidence on the beneficial role of positive psychosocial factors for health,[22,24,31,32] but the current study is the first to show an association between a broad set of positive childhood factors and the subsequent development of Type 2 diabetes. Previous studies on Type 2 diabetes have examined the role of specific harmful psychosocial childhood experiences on future diabetes.[17–19] The current study, in turn, suggests some distinct positive childhood factors that may protect against future diabetes. Children who encountered fewer life changes and whose

Table 2. Relative Risk Ratios (RRRs) of Adult Type 2 Diabetes and Prediabetes for 1 SD Increase in the Psychosocial Factors

	Outcome: Type 2 diabetes			Outcome: prediabetes		
Psychosocial subdomain	**RRR (95% CI)**	**Pseudo-R^2**	**Δ Pseudo-R^2**[b]	**RRR (95% CI)**	**Pseudo-R^2**	**Δ Pseudo-R^2**[b]
Favorable SES						
Model 1[a]	0.73 **(0.61, 0.88)****	0.011		0.92 **(0.85, 0.99)***	0.002	
Model 2[b]	0.79 **(0.65, 0.95)***	0.034	0.023	0.94 (0.87, 1.04)	0.025	0.023
Model 3[c]	0.83 (0.69, 1.01)	0.070	0.036	0.95 (0.88, 1.02)	0.031	0.006
Favorable emotional environment						
Model 1[a]	1.07 (0.89, 1.29)	0.000		0.97 (0.90, 1.05)	0.001	
Model 2[b]	1.02 (0.85, 1.23)	0.029	0.029	0.96 (0.89, 1.04)	0.024	0.023
Model 3[c]	1.03 (0.86, 1.23)	0.068	0.039	0.96 (0.89, 1.04)	0.031	0.007
Parental health behaviors						
Model 1[a]	0.71 **(0.60, 0.84)*****	0.015		0.94 (0.87, 1.01)	0.001	
Model 2[b]	0.72 **(0.61, 0.85)*****	0.042	0.027	0.94 (0.88, 1.04)	0.024	0.023
Model 3[c]	0.77 **(0.65, 0.92)****	0.077	0.035	0.96 (0.89, 1.03)	0.031	0.007
Absence of stressful events						
Model 1[a]	0.81 **(0.70, 0.93)****	0.006		0.91 **(0.86, 0.97)****	0.003	
Model 2[b]	0.87 **(0.75, 0.99)***	0.030	0.024	0.93 **(0.88, 0.99)***	0.025	0.022
Model 3[c]	0.86 **(0.75, 0.99)***	0.070	0.040	0.93 **(0.88, 0.99)***	0.032	0.007
Self-control of the child						
Model 1[a]	1.00 (0.82, 1.20)	0.000		0.96 (0.89, 1.03)	0.001	
Model 2[b]	0.94 (0.78, 1.13)	0.029	0.029	0.96 (0.90, 1.03)	0.025	0.024
Model 3[c]	0.95 (0.79, 1.13)	0.070	0.041	0.96 (0.90, 1.03)	0.031	0.006
Social adjustment of the child						
Model 1[a]	1.10 (0.90, 1.34)	0.001		0.96 (0.88, 1.05)	0.001	
Model 2[b]	1.11 (0.91, 1.35)	0.030	0.029	0.99 (0.91, 1.08)	0.024	0.023
Model 3[c]	1.13 (0.92, 1.37)	0.070	0.040	1.00 (0.91, 1.08)	0.031	0.007

Note: Boldface indicates statistical significance (*$p<0.05$; **$p<0.01$; ***$p<0.001$).
[a]Positive psychosocial score as predictor with no adjustments.
[b]Adjusted for age and gender.
[c]Adjusted for age; gender; childhood cardiovascular risk factors (insulin, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, triglycerides, systolic blood pressure, BMI); and childhood dietary behaviors (fruit, vegetable, meat, and fish consumption).

parents had healthy behaviors (exercise, healthy diet) were less likely to develop Type 2 diabetes.

Given that the burden of Type 2 diabetes is substantial —directly costing $245 billion each year[40]—there is an urgent need to develop novel strategies for targeting and preventing diabetes. The findings of the current study suggest that favorable overall circumstances play a protective role in Type 2 diabetes and its risk factors such as weight gain and rising glucose levels. This knowledge may be useful for early prevention efforts whereby targeted interventions may be delivered to families and children at risk.

Positive childhood factors were linked with lower rates of Type 2 diabetes through leaner BMI, but there may be other mediators as well. Some work suggests that positive social environments have favorable effects on biological stress regulatory systems. These include reducing likelihood of chronic sympathetic arousal or reducing inflammation in systems often occurring with high levels of psychosocial stress.[13,21,27,41] Positive experiences may also be linked indirectly with health outcomes by increasing the likelihood that individuals engage in healthy behavior (i.e., higher physical activity and consumption of healthier foods).[21,41,42] By contrast, children from less positive environments may be subject to food insecurity, high-calorie foods (which are often cheap), and fewer opportunities for recreation, further exacerbating the negative effects of family disadvantage.[43,44] One notable feature of Finnish youth is a high alcohol consumption rate and higher youth depression rate,[45,46] which usually are predicted by stressful family circumstances.[47] These may represent behavioral pathways from childhood circumstances to adult health outcomes.

Limitations

As with most long-running cohorts, one study limitation is the considerable number of people who dropped out from the study. The analyses of imputed data (N=3,553) may partially compensate for the possibility of bias introduced by missing data. Another limitation was that

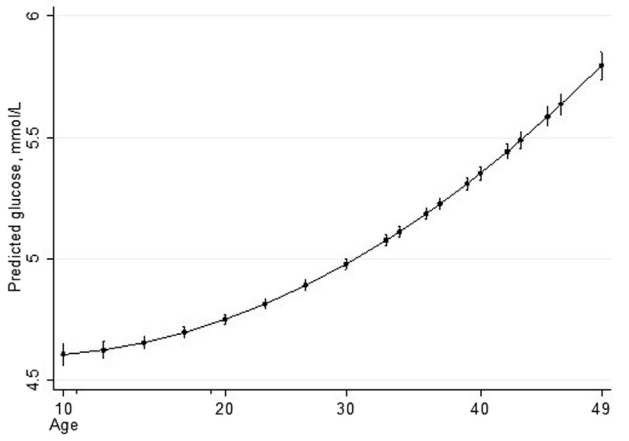

Figure 1. Growth curve of glucose (and 95% CIs) from childhood to adulthood.

the questionnaires on childhood factors were designed for this specific study more than 30 years ago, limiting the possibility to generalize over cohorts. The positive psychosocial score was used as a continuous variable to capture the full range of variance in a population in which a person can fall along the continuum in terms of how much of the attribute they have. According to previous recommendations,[38] each subscore was treated as having equal weight, and the total summary score made it possible to examine the effects over several exposures. Finally, the findings can be generalized to the white European population with access to public health care, leaving a need to conduct similar studies among diverse populations with different healthcare systems.

Strengths of this study were the prospective assessment of a relatively wide spectrum of childhood psychosocial factors when the participants were children, the assessment of Type 2 diabetes from national register that covers 100% of the population and from clinical assessments, ability to control for the confounding effect of childhood cardiovascular risk factors, and capacity to examine longitudinal trajectories in glucose development from childhood to mid-adulthood.

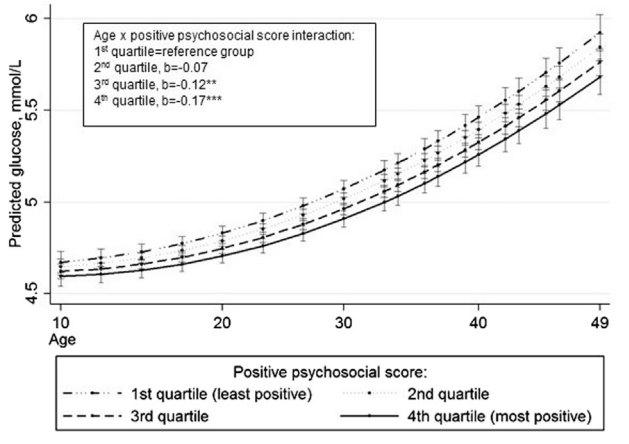

Figure 2. Growth curve of glucose (and 95% CIs) in quartiles of the total positive psychosocial score in childhood.

CONCLUSIONS

Having a broad set of positive psychosocial factors in childhood seems to be associated with healthier body weight in adulthood and healthier glucose trajectories over the life span, thereby protecting against Type 2 diabetes. Whether interventions directed at early-life circumstances are warranted remains to be examined in RCTs. The current findings suggest that child psychosocial factors have a role in the development of diabetes, and this knowledge may provide new insight for building prevention strategies to mitigate the epidemic of diabetes.

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SUPPLEMENTAL MATERIAL

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